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THE FERTILIZATION OF FLOWERS BY INSECTS AND THEIR MUTUAL ADAPTATION FOR THAT FUNCTION.*

THE old idea, once a favorite topic with poets and divines, that the beauty of the external world was intended exclusively to promote the enjoyment of mankind, has suffered many severe shocks from the rude onslaughts of modern science. The discovery that the earth was a habitable and inhabited world, countless ages before man appeared upon the scene, might be explained on the hypothesis that it was thus becoming prepared for the advent of the masterpiece of creation; the egotism of the human species might even survive the discouraging fact that gems of purest ray serene were born in the unfathomed caves of Silurian or Devonian oceans, and that flowers of the most perfect beauty were born to blush unseen in the midst of oölite or cretaceous deserts. The un pitying theory of the survival of the fittest, however, points relentlessly to the conclusion that man after all is not the *raison d'être* of anything he sees around him except himself; that “jedes für sich” is the rule of nature; that every organic being is contrived so as to have the best chance of supplying its own wants, and not for the sake of administering to the wants of others; in fact that the philosophy of science must, for the future, be an application to the realms of nature of the principle of self-love, such as even a Hobbes might accept.

The volume before us, though full of minute details of empirical observation, is an important contribution to this philosophy of science. The main fact which forms the groundwork of Prof. Müller's observations is not new. Towards the close of the last century one of the keen observers of nature with which that period abounded, C. C. Sprengel, in his *Das entdeckte Geheimniss der Natur im Bau und in der Befruchtung der Blumen*, pointed out that a number of the different forms which the flowers of plants assume are obviously contrived for the purpose of attracting insects and of enabling them to carry away the pollen which is required to

* *Die Befruchtung der Blumen durch Insekten und die gegenseitigen Anpassungen Beider. Ein Beitrag zur Erkenntniss des ursächlichen Zusammenhanges in der organischen Natur.*—Von Dr. Hermann Müller. Leipzig: Engelmann.

fertilize other flowers of the same species. This line of research, which had been almost lost sight of since Sprengel's time, has been renewed in our own day by Darwin in this country, the writer of this volume and Hildebrand in Germany, Axell in Sweden, and Delpino in Italy; the first-named naturalist reducing the sum of his observations to the well-known aphorism that "nature abhors perpetual self-fertilization." The whole of that complicated structure which we call in ordinary language the "flower" of a plant consists, in fact, of the reproductive organs enclosed in a number of envelopes which have for their purpose not only the protection of the essential organs within them, but the attraction of those insects or other animals which are necessary for the fertilization of the ovules.

The contrivances for effecting this purpose, though infinite in number and variety, may be classed under two principal heads, color and scent. A large number of insects obtain their food chiefly or entirely from the juices of flowers; and the necessity for cross-fertilization renders the visits of these insects as indispensable to the life of the flower as to that of the insect. To enable them to find this food the juices are very commonly scented; a field of clover or beans will attract all the bees in the neighborhood from a great distance; and, if carefully watched, the bees will be found not only to carry off with them the honey, but to transfer also a portion of the pollen from flower to flower. Where the juice of the flower does not happen to be scented, the bright color of the corolla commonly serves the purpose of attracting insects from a distance. Different insects and other small animals have apparently very different ideas of beauty as regards the form and color of the flower. Hummingbirds are said by Delpino to have a penchant for scarlet and for flowers with long wide tubes; hence in countries where there are no hummingbirds, as our own, scarlet flowers or those with long wide tubes are very rare among native plants.* The largest-flowered of European plants, the peony and several species of convolvulus, are visited chiefly by large beetles allied to the cockchafer; and as we proceed farther north to climates too cold for this description of insect, the corresponding flowers also disappear, not being able to mature their seeds without assistance. When fertilization is effected by very

* Among our common wild flowers it would be difficult to name any of a true scarlet hue except the poppy and the little pimpernel.

small insects, something more than a large conspicuous corolla is required to show the visitors the way to the nectary or receptacle for the honey; hence arises the variegation of flowers, the bands or patterns of color being almost invariably so arranged as to direct the insect in the way it should go in search of food. As nature seldom provides two contrivances, concurrently, for the same purpose, we find that variegated (wild) flowers are seldom scented; while the most odoriferous flowers are almost always uniform in color; the evening primrose, which opens its scented flowers only in the dusk, requires no variegation to direct the night-flying moths to the scented nectar.

Illustrations of all these laws have been observed by the naturalists we have mentioned, and have been collected with great industry in this volume by Dr. Müller, himself no idle worker in the same field. According to the theory of natural selection, those descendants from a common ancestor which vary from the others in any direction that tends to increase their attractiveness to insects, or to secure a more certain transference of the fertilizing pollen from one flower to another, will have the best chance of survival and of perpetuating and increasing this peculiarity in their progeny. Dr. Müller has himself examined, or records the observations of others on, nearly four hundred species of plants, and describes the structure of the reproductive organs and of their envelopes, with especial reference to their adaptation for self-fertilization or for cross-fertilization, giving in each case a list of all the insects which have been observed to visit the flower, and illustrating his description, where necessary, by admirable woodcuts. This portion of the subject is more or less familiar to most botanists; what Dr. Müller has made peculiarly his own study is the tracing out of the same principle, applied to the visiting insects, as previous observers have noted with respect to the visited flower. By the same principle of natural selection those insects which display to the greatest perfection contrivances for extracting the honey of flowers or for carrying away the pollen — the latter serving in some cases for their own food, in others for storing up in their nests as food for the larvæ or young — will stand the best chance of perpetuating offspring provided with the same peculiarities; and we find here abundant descriptions and drawings of the various forms which these contrivances assume in different classes of insects.

In his concluding chapter Dr. Müller discusses the origin of

these phenomena, and declares himself a firm adherent of Darwin's theory, finding the explanation of every special contrivance on the one side or the other in the principle to which we have already referred. He therefore vigorously combats the teleological views of Sprengel and Delpino, the latter of whom especially, while accepting the theory of evolution or descent with modification, yet disputes the soundness, or at least the adequacy, of the other theory usually associated with it, that of natural selection. He recurs, in fact, to the pre-Darwinian doctrine of design, to account for the phenomena which furnish the subject of this work, or, as Müller represents him: "Nature is with him a being endowed with human thought, which has invented definite forms of flowers leading necessarily to cross-fertilization; and this is then completely carried out by the employment of different parts of plants for the same purpose. This creator of flowers, far exceeding in talent the cleverest man, has predestined certain forms of flowers for certain insects, and certain insects for certain forms of flowers, and has contrived each one to fit the other." The reasons which may be adduced against this theory would be simply a repetition of the main argument of Darwin's *Origin of Species* and *Variation of Animals and Plants under domestication*. The believer in the doctrine of natural selection finds it more consonant with the facts which he sees around him to assume that Nature—if it is possible to personify the idea—works, not by preconceived notions and prearranged harmonies, in which case we should expect to find everything perfect, without discord, waste, or incompleteness; but rather, as a human workman would act, tentatively; making small improvements here and slight adaptations there; every form of life, in fact, constantly approaching a more and more perfect adaptation to the circumstances in which it is placed, a perfection which, however, is never absolutely attained.

There are few regions of scientific inquiry more easily open to any observer resident in the country and possessed of ordinary powers of observation, than those connected with the fertilization of flowers, and none which would more amply repay careful research by leading to further insight into the still hidden laws which govern the origin of species. To all workers in this field Dr. Müller's elaborate and in every respect admirable work will be an indispensable companion.—A. W. BENNETT, *in the Academy*.